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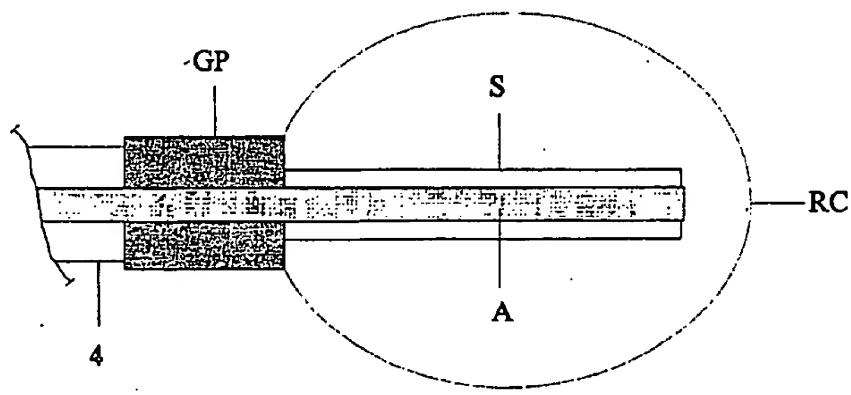

(57) Abstract

A probe for a microwave apparatus for clinical and surgical treatment of tissue in vivo, especially intra-uterine treatment of the endometrium by means of hyperthermia, is supplied with microwave energy from a microwave generator provided in the microwave apparatus via a coaxial cable. The coaxial cable is terminated in such a manner that it acts as a microwave radiator (A) in the form of an exposed section of the end of the inner conductor of the coaxial cable (4) and a ground plane (GP) provided behind the exposed section (A) of the inner conductor. The ground plane (GP) thereby constitutes the transition between the microwave radiator (A) and the coaxial cable (4), the length of the ground plane (GP) being greater than the length of the microwave radiator (A). This means that the probe acquires an approximately isotropic, symmetrical radiation characteristic without backwardly-directed radiation lobes, which in turn means that its positioning in the uterus is not critical and eliminates the risk of damage to tissue which is not intended for treatment. This makes the probe especially suitable for sterilization of women under primitive conditions.

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A probe for a microwave apparatus for clinical and surgical treatment

The invention concerns a probe for a microwave apparatus for clinical and surgical treatment of tissue in vivo, especially intra-uterine treatment of the endometrium by means of hyperthermia, wherein the probe is supplied with microwave energy from a microwave generator provided in the microwave apparatus via a coaxial cable which is terminated in such a manner that it acts as a microwave radiator.

In US-PS no. 4 057 063 there is disclosed a device for sterilizing women by transuterine coagulation of the tubes which lead to the uterus, wherein there is used a high frequency generator and a probe connected thereto which constitutes an active electrode. The sterilization takes place by sealing the lumen of the tubes which lead to the uterus by electrical coagulation of the tissue. Furthermore US-PS no. 4 292 960 discloses an apparatus for employing radioactive and microwave energy on the walls of an internal organ in the body such as the uterus. EP patent application no. 0 459 535 discloses an apparatus for surgical treatment of tissue by means of hyperthermia. The apparatus comprises a device for generating microwave energy, which device is located in a probe which can be inserted into one of the body's cavities, e.g. through the urethra in order to treat the prostate gland, but this requires a high degree of accuracy with regard to positioning.

One problem with microwave probes which are used for hyperthermal treatment of tissue in vivo is that the temperature in adjacent tissue and organs has to be kept under close supervision in order to prevent them from being damaged.

The radiation characteristic of the above-mentioned and other known microwave probes is of such a nature that a part of the energy is absorbed by tissue and organs which are not meant to be treated, with the risk of causing them permanent damage, while at the same time the energy supplied to the organ and tissue for which the treatment is intended is less than the optimum. In order to remedy this situation, monitoring is undertaken of the temperature of tissue and organs adjacent to tissue and organs which are to be treated. Alternatively the impedance in adjacent tissue and organs can be monitored, the treatment being discontinued when the impedance exceeds a fixed value. In addition devices are employed in the prior art in order to increase the energy supplied to the area which has to be treated, e.g. by using microwave-reflecting devices which, e.g., can be inserted into adjacent cavities, thereby avoiding the disadvantages associated with an asymmetrical radiation characteristic.

Nevertheless, the known devices for microwave treatment with hyperthermia make demands on the operator's experience and accuracy if the risk of damage is to be substantially eliminated and the said devices are also often complicated, which makes them difficult to use under primitive conditions.

Thus it is desirable to provide a microwave probe which is simple to operate and use, without entailing the risk of inadvertent tissue damage to the patients. In particular it is desirable to provide a microwave probe which can be used with an apparatus for treatment of the endometrium in women with a view to coagulation or destruction of the endometrium, the apparatus being used in this context inter-uterinely in order to treat, e.g. haemorrhages in the uterus or to effect the sterilization of the women. At the same time it is also desirable that the apparatus should be so simple and safe to use that it is suitable, for example, for sterilizing women under primitive conditions, e.g. in developing countries. Finally it is desirable to provide a microwave probe with an isotropic and symmetrical radiation characteristic without sidelobe effects.

The above-mentioned and other objects are achieved with a probe according to the invention which is characterized by the probe comprising a combination of the microwave radiator in the form of an exposed section of the end of the coaxial cable's inner conductor and a ground plane provided behind the exposed section of the inner conductor, the ground plane constituting the transition between the microwave radiator and the coaxial cable which supplies microwave energy to the probe, the length of the ground plane being greater than the length of the microwave radiator.

Further features and advantages of the probe according to the invention are presented in the attached independent claims.

The invention will now be explained in more detail in connection with an embodiment and the attached drawing.

Fig. 1 is a schematic illustration of the probe according to the invention.

Fig. 2 illustrates the probe employed in a microwave apparatus suitable for intra-uterine use.

The probe according to the invention is illustrated schematically in fig. 1. The probe 1 consists of an exposed section A of the inner conductor of the coaxial cable 4, together with a ground plane GP provided around an adjacent section of the inner

conductor of the coaxial cable 4, the ground plane thus forming the transition between the radiator A and the coaxial cable's outer conductor. The radiator or antenna A is a quarter-wave radiator, i.e. its length is a quarter λ, possibly with the addition of a correction factor. The preferred length of the ground plane GP is 1.05 times the length of the radiator A and will depend on the frequency of the microwave energy employed and the desired radiation characteristic of the radiator A.

In fig. 1 the radiation characteristic RC is indicated by the dotted line, as it appears in the axial plane of the radiator A. It can be seen that the radiation characteristic RC is approximately symmetrical about the axis of the radiator A as well as also being approximately isotropic. The radiation characteristic will appear in a corresponding manner in the radial plane, i.e. as symmetrical and isotropic. Thus the energy radiated from the probe 1 is approximately equal in all directions and it is not critical how the probe is applied in the uterus, since it does not exhibit any directional effects. While the ground plane GP helps to give the desired radiation pattern, it also simultaneously prevents the radiation characteristic from showing backwardly-directed sidelobes. Thus with the present design of the probe 1, its location in the uterus is not critical and it can be operated without risk by even an inexperienced operator and under primitive conditions.

When in use the radiator A will normally be protected by a shrink stocking S, thus avoiding damage to the patient. As already mentioned, the probe 1 according to the present invention is specially suited to treatment of the endometrium in women, the absorption of microwaves in the endometrium causing cauterization or coagulation of the blood vessels with destruction of the cell tissue. The probe according to the present invention can therefore be used for the treatment of intra-uterine haemorrhage in women. Since the probe causes destruction of the endometrium, it is also well suited to the sterilization of women.

With the use of the probe 1 according to the invention for sterilization, the surgical intervention is absolutely minimal. The probe 1 which is approximately 4 cm long and has a diameter of approximately 3 mm, is inserted into the uterine cavity and the patient is exposed to microwave radiation for a period of time which will vary from patient to patient. Apart from the coagulation of the endometrium the uterus is not affected as an organ, but is kept intact. The treatment can, for example, be performed under a local anaesthetic, usually PCB (paracervical blocking).

Fig. 2 illustrates how the probe 1 according to the invention is used together with a microwave apparatus 5. The probe is then connected to a microwave generator 6 in the microwave apparatus 5 via the coaxial cable 4. The microwave apparatus can also be connected to a first temperature sensor 2 in order to record the temperature in the bladder and a second temperature sensor 3 in order to record the temperature in the rectum. The use of the temperature sensors 2, 3 during the treatment will further reduce a hypothetical risk of tissue damage outside the area which has to be treated with the probe 1. As already mentioned, with the probe according to the present invention this risk is extremely small, but nevertheless the use of the temperature probes represents an extra safety measure during the operation.

A preferred version of the microwave apparatus weighs approximately 10 kg and the microwave generator 6 may typically emit a frequency of 2.45 GHz. At this frequency the power output of the microwave apparatus is, e.g., 600 watts. This output will diminish between the microwave generator 6 and the probe 1 due to loss in the coaxial cable 4, the energy radiated from the radiator A thus normally lying between 20 and 100 watts, depending on the regulation of the microwave generator's output.

In calorimetric tests with full output on the microwave generator, during the course of 1 minute the radiator A emitted approximately 5000 joule, i.e. the effect radiated was approximately 80 watts. In a volume of water of 150 ml this led to a temperature rise of approximately 8°. Thus it can be seen that the risk of tissue damage outside the area which has to be treated is minimal, and with a reduction of the output this risk is further reduced, while at the same time the positioning of the probe in the uterine cavity is not critical, since the output of the microwave radiation is more or less exclusively restricted to the endometrium. According to the present invention a probe is thereby provided for treatment of the mucous membrane of the uterus without risk to the patient while at the same time being inexpensive and simple to use.

PATENT CLAIMS

1. A probe (1) for a microwave apparatus (5) for clinical and surgical treatment of tissue in vivo, especially intra-uterine treatment of the endometrium by means of hyperthermia, wherein the probe (1) is supplied with microwave energy from a microwave generator (6) provided in the microwave apparatus (5) via a coaxial cable (4) which is terminated in such a manner that it acts as a microwave radiator (A), characterized in that the probe (1) comprises a combination of the microwave radiator (A) in the form of an exposed section of the end of the inner conductor of the coaxial cable (4) and a ground plane (GP) provided behind the exposed section (A) of the inner conductor, the ground plane (GP) thus constituting the transition between the microwave radiator (A) and the coaxial cable (4) which supplies microwave energy to the probe (1), the length of the ground plane (GP) being greater than the length of the microwave radiator (A).

2. A probe according to claim 1, characterized in that the microwave radiator (A) is a quarter-wave radiator.

3. A probe according to claim 2, characterized in that the length of the microwave radiator (A) is 0.25 times the wavelength of the microwave energy supplied multiplied by a correction factor.

4. A probe according to claim 3, characterized in that the length of the ground plane (GP) is 1.05 times the length of the microwave radiator (A).

5. A probe according to claim 4, characterized in that the microwave energy supplied has a frequency of 2.45 GHz.

6. A probe according to claim 5, characterized in that the energy radiated lies between 20 and 100 watts.

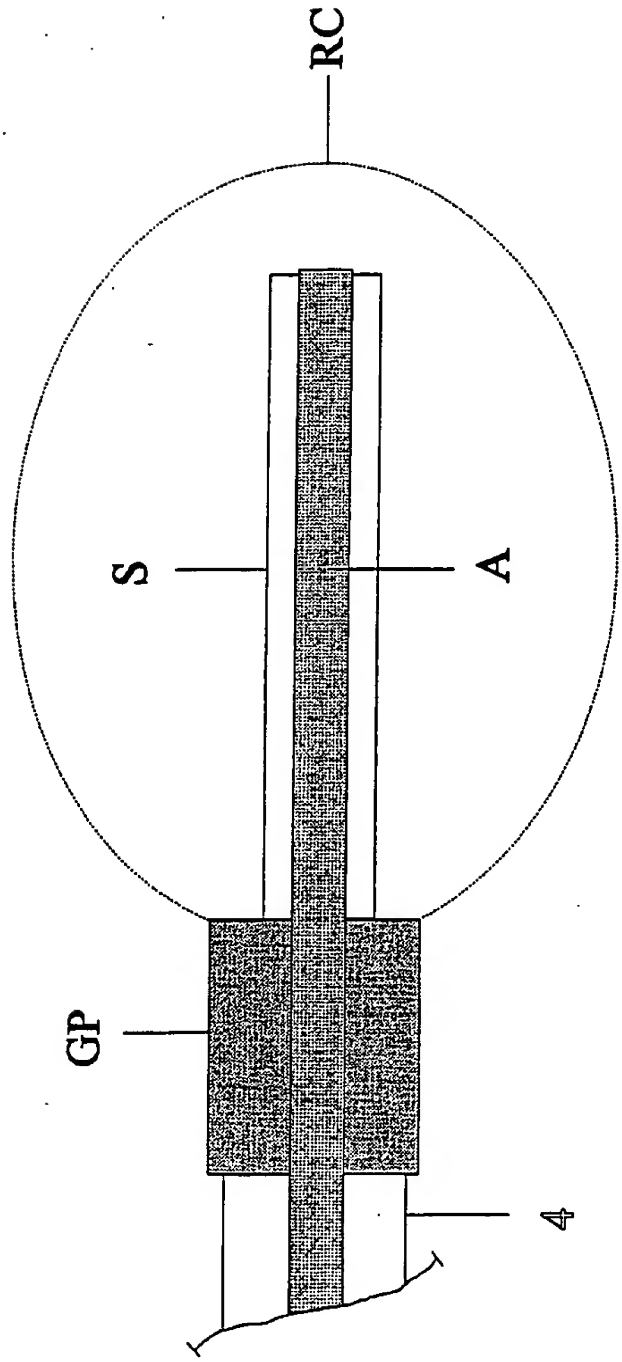

Fig. 1

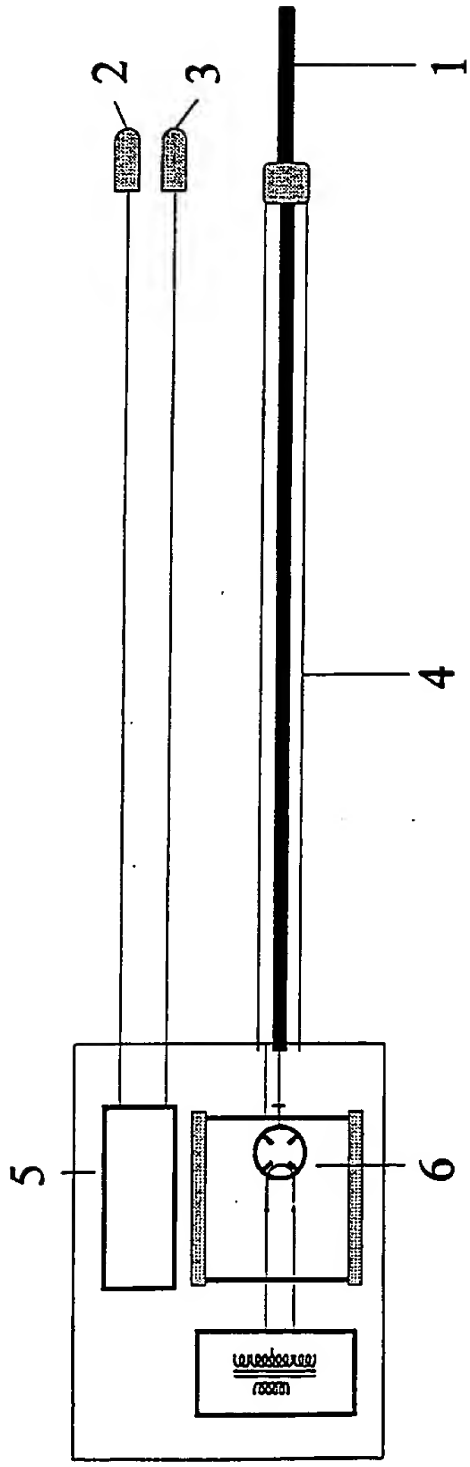

Fig. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO 94/00137

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: A61N 5/04, A61B 17/39
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: A61B, A61F, A61N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP, A2, 0521264 (W.L. GORE & ASSOCIATES GMBH), 7 January 1993 (07.01.93), figure 1, abstract --	1
X	WO, A1, 9102560 (DEUTSCHES KREBSFORSCHUNGSZENTRUM), 7 March 1991 (07.03.91), claim 1, abstract --	1
X	US, A, 5220927 (MELVIN A. ASTRAHAN ET AL), 22 June 1993 (22.06.93), column 12, line 20 - line 28, figure 7, abstract --	1

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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A	DE, C2, 3831016 (DEUTSCHES KREBSFORSCHUNGSZENTRUM STIFTUNG DES ÖFFENTLICHEN RECHTS), 19 November 1992 (19.11.92), figure 1, abstract --	1

INTERNATIONAL SEARCH REPORT

Information on patent family members

29/10/94

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		JP-T- 4504218	30/07/92
US-A- 5220927	22/06/93	EP-A- 0462302	27/12/91
		US-A- 4967765	06/11/90
		US-A- 5249585	05/10/93
		US-A- 5344435	06/09/94
US-A- 4448198	15/05/84	NONE	
DE-C2- 3831016	19/11/92	NONE	